Increasing Student Motivation Thru Development and Grading of Examinations and Homework

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Abstract

Tests, homeworks, and the associated grading policy and course management all play key roles in student perception of a course, and ultimately the program. A perception of unfairness, real or imagined, can decrease student motivation to learn, or in more serious cases, result in the students giving up on the course entirely, or even changing their major. In large enrollment courses that are taught by several instructors, there can be the problem of student perception with inequity in the difficulty of the versions of the examinations and homeworks issued, and the subsequent grading of these exams and homework. The starting point in developing 'fair' examinations is to develop appropriate and pertinent test questions. Examination questions should follow from the lesson objectives, which come from the course objectives. The course objectives should support the program objectives, which in turn are guided by ABET criteria. How do you link these pieces together to write a good examination? Additional questions quickly follow. What problem type or types should you use: Multiple Choice, True/ False, Short Answer, Short Calculation, Long Calculation, etc.? How many versions of an examination are necessary? What are the advantages and disadvantages of giving the examinations during the regular class periods, verses during an available common hour for the students of all the instructors? This paper will discuss possible solutions to these questions, as well as how to effectively use multiple graders, and the role of the restrictive and sometimes controversial cut scale. Student course assessment data will be presented to illustrate the positive and negative effect on student motivation, i.e. learning, when there is a perception of unfairness in the examinations or homework issued and/or subsequent grading.

Introduction

In the over 200 years West Point has been an undergraduate institution, it has consistently determined that students learn best in small sections of about 16 to 18 students. In order to facilitate and encourage additional discussion or tutoring to students after formal class periods, grade and assess student work, and prepare each lesson, the maximum teaching load that an instructor can effectively handle is four of these small sections. In our large enrollment courses that have more than 1,000 students, the course requires fifteen or more instructors. Most courses at West Point, including our electives, have multiple instructors. Theses multiple instructor courses work best when they are managed by one instructor – the course director. The course director is responsible for ensuring consistent content and grading philosophy throughout the course. The best technique for ensuring consistency is for the course director to write all the examinations and design problems, and occasionally the homework assignments as well. Consequently, the course director only teaches a maximum of two of these small sections.

In this system, the course director has several concerns, especially about examinations. First, he must ensure all the instructors have adequately covered all the central concepts in the course. Second, he must craft an examination that is clearly written, and tests those important concepts. Third, he must decide when to administer the examination, and how many versions of the examination are required. Fourth, a grading plan is needed to ensure consistent grading of the examinations. Last, the course director must capture the lessons learned from developing and administering the examination and use the information to improve the course in the future.

Course Development

Proper course development is the first and most important step in crafting good exams. There are numerous other papers that discuss course development in detail, so only a short summary of the method used by the authors will be presented here.

Each course assists the program in meeting program outcomes through teaching essential topics that build towards fuller understanding. A course can be developed by breaking it into manageable pieces. First, you decide on course objectives. Part of this process is deciding on the central topics to cover, focused on the course objectives, and the amount of time to spend on each. The course objectives cover the essential topics and are relevant and important to the mastery of the course material. Each objective should be measurable or observable.

The next step is to decide on the cognitive skill level you want to test each of the course objectives at. Bloom has identified a hierarchy of six cognitive skill levels: knowledge, comprehension, application, analysis, synthesis, and evaluation.[1] Knowledge is demonstrated by the recall of information. Understanding and interpreting information is classified as the comprehension level. Application is the use of methods or concepts to solve problems. Recognition of patterns or the organization of components characterizes the analysis level. The synthesis skill level involves creating new knowledge from different areas or creating new ideas from old ones. The evaluation skill level is the ability to compare choices or ideas.

The end result is a complete list of course objectives to include any secondary topics, written at the cognitive skill level you have determined you want the students to understand the material at. Too many course objectives are written at the lower three levels. Effort should be placed on pushing objectives into the higher three levels. Now the course objectives are arranged in a desired order with the associated number of lessons to cover the material. For each lesson, specific learning objectives are then developed. For example, in our Mechanics of Materials course, a course objective requiring two lessons to cover would be:

- Given a state of stress at a point, determine the principle stresses (σ_1 & σ_2) and the maximum in-plane shear stress (τ_{max}), the angle to the principal plane (θ_p), and the state of stress on any plane through the point ($\sigma_{x'}$ & $\tau_{x'y'}$).

One of the associated lessons on Stress Transformation would have the following Lesson Objectives:

- Given a state of plane stress, solve for normal stresses and shear stresses on different planes.
- Given a state of plane stress, solve for the principal (maximum and minimum) normal stresses (σ_1 and σ_2), and maximum in-plane shear stress (τ_{max}).

The next step is to write lesson plans that cover the learning objectives for that lesson. We use Board Notes to identify, formulate, script, and rehearse how and what will be discussed and presented on the chalkboard. Board Notes allow us to boil down presented material to the irreducible minimum.[2] Figure 1 below depicts one page of Board Notes used by one of the authors to teach a lesson on Stress Transformation. Generally, the board notes should include both the pertinent theory for the lesson, and an example problem that illustrates the principle covered. Each block represents what, where, and how the minimum material is best presented for a distinct section of blackboard space. Some instructors use four blocks (as shown in Figure 1) and others place six blocks on a sheet of paper based on their experience relating paper size to board space.

The final step is to review the course to ensure the material and the lessons transition smoothly from topic to topic. Adequate coverage of course objectives is accomplished through efficient coverage of lesson objectives through well thought out board notes.

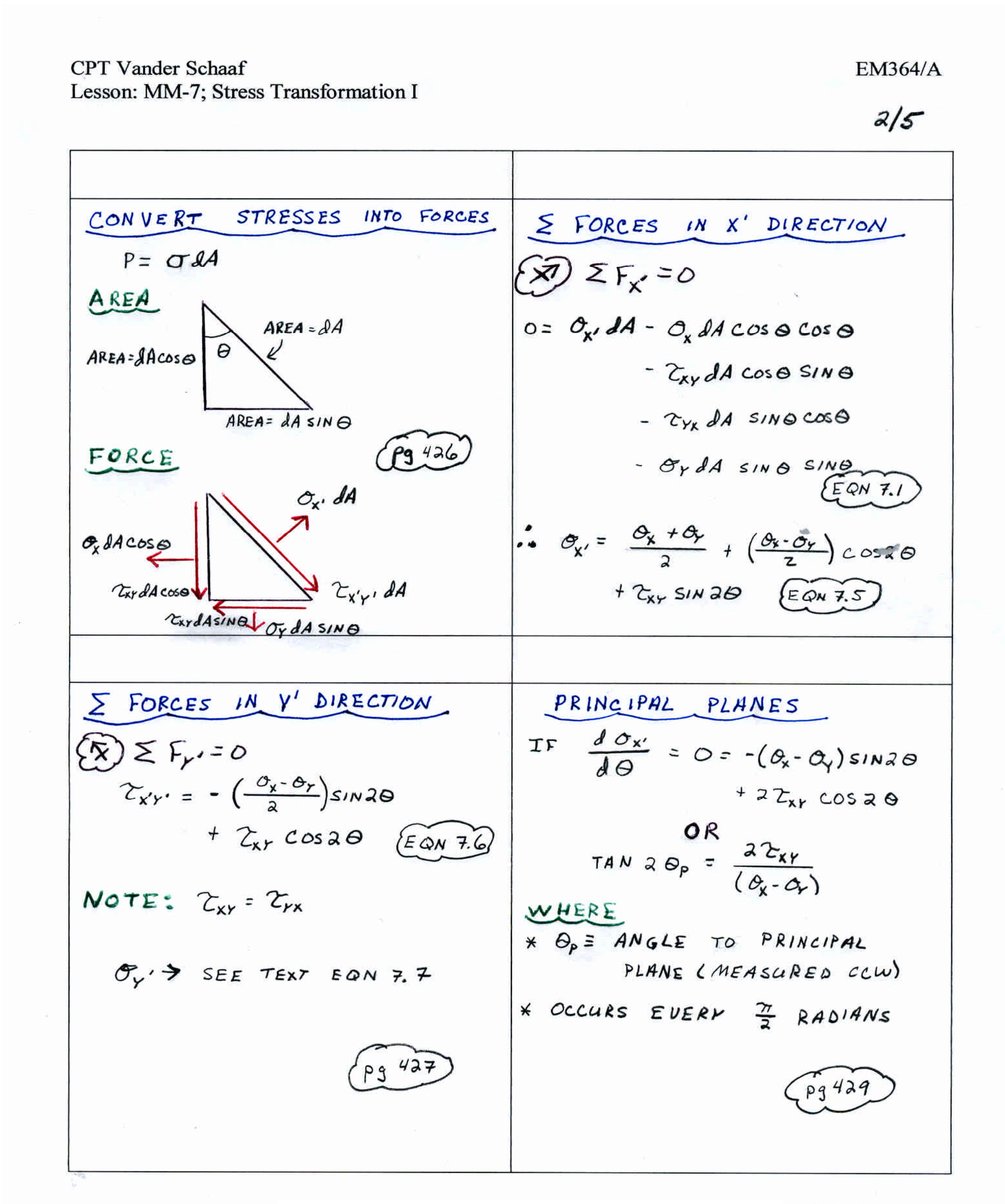

Figure 1: Example Board Notes

Course Management

There are many ways to manage a course when multiple instructors are teaching it. One way is to establish a loose framework for the course and allow each instructor to operate separately, creating his own homeworks and exams. This has the advantage of being very easy to manage, and keeps many of the instructors happy because they are free to edit the course content as they like, and test whatever they determine appropriate. However, it is very hard to ensure all instructors adequately cover the course content presented in the course catalog. Other possible disadvantages are that follow-on courses depend on certain material being taught and student motivation and sense of fairness may suffer. Future courses in the major may receive students that are disadvantaged since they have not seen all previous course material. Additionally, if the actual or perceived workload, quality/quantity of homework, exam difficulty, and/ or the grading varies significantly between instructors, significant student motivation problems can develop.

At West Point a single course director, who has taught this course a number of times before and fully understands the connectivity of all the course objectives, manages the course. The course director is responsible for ensuring that consistent content and grading philosophy is followed by all the instructors in the course. Since the course director develops all examinations, one of his primary concerns is that all the instructors in the course cover the same topics. Otherwise, students whose instructor has not covered a topic that is on the exam are severely disadvantaged. To help ensure consistent content through out the course, the course director typically provides all the instructors teaching the course a copy of his board notes (Figure 1), and holds regular lesson conferences to review the content for each block of lessons. All instructors are expected to create their own board notes and to tailor the lesson based on their experience and background. However, the course director's board notes let everyone know what the course director is covering, and at the lesson conferences the course director ensures all the instructors understand fully what the central topics are that must be covered. This keeps everyone focused on the essential course and lesson objectives. Additionally, the decreased course administration requirement for the other instructors teaching the course should provide them with additional time for other areas: research, committee work, etc.

<u>Exam Development</u>

Examinations consist of a large percentage of course points and cause the greatest amount of stress in our students. If we can ensure they feel that the examinations are fair, then we can decrease stress levels and build positive rapport with them which usually will translate into greater learning. The first step in creating an effective examination is to determine what material to test. The place to start is with the course objectives. The course objectives, as discussed above, should be relevant and important to the mastery of the course material, and should be measurable or observable. Properly developed course objectives should directly lead to a test question. Once you have selected the course objectives to test on this exam, the next step is to decide on the problem type or types to use, e.g., Multiple Choice, True/ False, Short Answer, Short Calculation, Long Calculation, etc. All course objectives should be tested, but not all will be tested on examinations. Some can only be tested on design problems or in homeworks.

Most exams will and should include a combination of problem types. This facilitates testing course objectives at different cognitive levels, and does not overly favor students who prefer and do better on one particular exam type.[3] Additionally, the Fundamentals of Engineering Examination is primarily multiple choice, so some questions in this format is entirely appropriate. Rarely, however, is it appropriate in upper-division engineering courses to construct an exam composed solely of multiple choice and True/ False questions, even though the Civil Engineering Principals and Practices Exam is entirely multiple choice. The all or nothing grading of these questions does not differentiate between a math error and a conceptual error made in solving a problem. The amount of work and the thought process required to solve problems at the higher cognitive skill levels do not lend themselves to fragmenting into the small pieces required for multiple choice and True/ False questions. Short or long calculations are probably more appropriate for these types of questions when first encountered, and credit should be assigned for all correct work. The exam questions should be carefully and concisely worded. Imprecise terms, slang, and unfamiliar jargon should be avoided, and the questions written at the level of the average student.

The final step in writing an examination is reviewing the entire exam. A method we use is for each of the instructors who have not seen the exam to take all versions of the exam for time. Typically, we consider instructor times of 17 to 19 minutes to correspond to an appropriate length 55-minute exam (or 1/3 time for instructors). Additionally, it is critical for the instructors to meet after taking the exams to verify answers, modify wording of unclear questions, correct typographical errors, and to discuss and if required to modify the cognitive level, difficulty, or importance (points assigned and time required to solve) of any question. A key component of this exam procedure is that every instructor must feel comfortable with the exam, and certain they have taught or facilitated the learning of their students' mastery of course objectives. Even if you are the sole instructor for a course, it is important to have someone take and review your exam.

Exam Administration

There are a couple of other questions to answer when developing an exam. How many versions of an examination are necessary? What are the advantages and disadvantages of giving the examinations during the regular class periods verses during an available common hour for the students of all the instructors?

If the exam is given at a time common to all the students in the course, only two versions of the exam are probably required, a primary and a makeup version. The advantage of giving the exam during a common hour is that most of the students, regardless of instructor, take the exact same exam at the same time. This eliminates the potential for a group of students to receive an easier or more difficult exam, and greatly reduces the chance that some students perceive an inequity in the varying exams given. Sometimes multiple offerings of a course are scheduled for the same period, so the same exam could be used. At West Point, we have an hour classified as Dean's Hour after lunch to allow meetings of an entire course. Besides lectures and labs, the hour is used to test the entire course at one time. However, in Mechanics of Materials, we have administered exams during West Point's Dean's Hour, and had 35 out of 172 students miss the exam for authorized reasons - conflict with another exam or lab given at the same time, sports team trip, etc. This eventually required administering four makeup exams, and was a significant headache to track and coordinate.

Administering exams during the regular class period has the advantage of limiting or eliminating the number of students that will have conflicts and require makeup exams. Mechanics of Materials typically has 100 to 180 students, in six to ten sections, with three to five instructors. To administer the exam in class, three to four versions of the exam plus possibly a make-up exam are typically required to ensure that no student receives an unfair advantage by learning exactly what's on the exam from another student before taking the exam himself. The primary disadvantage of in-class exams is ensuring all the versions of the exam evaluate the essential course objectives at the same cognitive level and degree of difficulty. This requires extra care during exam development. Many of these problems are solved when the other instructors take the exam.

Grading

Decide how to grade the exam before it is given. At West Point, to ensure consistency and fairness, one instructor will grade a problem for the entire course, not just his students. For example, if there are three instructors in the course and four problems on the exam, put the two shortest questions together so one instructor grades the two shortest questions on all of the exams, and the other instructors each grade one of the longer questions. This method is also more efficient. An instructor is only looking at one or two problems, so after grading the first ten to fifteen exams, the instructor will be familiar with the solution and the common mistakes, and will be able to grade the remainder of the exams more efficiently.

The cut scale to be used to grade the exams can be developed by either the course director or an instructor, and then reviewed by the course director. The cut scale should be detailed, but possibly will not be complete. The primary grader will finish developing the cut scale by grading the first ten or so exams, tweak the cut scale, then regrade the first exams before grading the rest of the examinations. A properly developed cut scale ensures consistent and equitable grading of all exams. By filing and maintaining cut scales, previous cut scales can be used as a base for developing future cut scales. Additionally, there is the added benefit of maintaining consistency in the grading from semester to semester.

Program Development

Every year, each course director conducts an assessment of their course with, as a minimum, the program director present. Course and lesson objectives and course content are discussed in a meeting open to everyone in the department, where a decision is made on the content of the course for the following year. Each of the course assessment meetings are part of the ABET fast loop cycle done every year, that feed into the program development slow loop cycle completed once every three years to examine the Program Outcomes and Objectives. If there is disagreement among the faculty about what should be in the course, the program director makes the final decision. There is a continuous cycle of receiving and using both student feedback and faculty input to constantly improve a course.

Every semester, the students in the course are asked to assess their mastery of each of the course objectives. The course director also provides his assessment with comments as needed, usually before seeing the students' assessment. The results for the Mechanics of Materials course at West Point for the Fall 2000 (AY 01-1) semester and the Fall 2001 (AY 02-1) semester are shown in Table 1 below. Note: only the results for the first 13 course objectives are presented for brevity. Course objectives assessed equally low by students and faculty alike are closely evaluated to determine what changes are necessary to ensure students master the concepts associated with the course objectives. Table 2 below presents the course director's (CD's) assessment of the contribution of the Mechanics of Materials course to the Civil Engineering Program Outcomes. Not every course can contribute in every area, but collectively the courses contribute to program outcomes and objectives.

Table 1: Assessment of Course Obiectives

WERE COURSE OBJECTIVES ACHIEVED? 1=UNSAT 2=MARGINAL 3=SAT 4=GOOD 5=EXELLENT

End of Course Questions	Cadet Assess 01-1/ 02-1	Course Director Assess	Course Director's Remarks
(1) Determine internal forces (axial forces, shears, moments, & torques) in a structural member.	4.35/4.38	4	Fairly typical performance
(2) Analyze/design a centric axially loaded (2 force) member.	4.43/4.36	4	
(3) Given a state of stress at a point, determine the principle stresses (σ_1 & σ_2) and the maximum in-plane shear stress (τ_{max}), the angle to the principal plane (θ_p), and the state of stress on any plane through the point ($\sigma_{x'}$ & $\tau_{x'y'}$).	4.07/3.95	3.5	Those who couldn't, couldn't.
(4) Determine the axial deformations (δ) and/or normal stress (σ) in a centric axially loaded (2 force) member due to applied loads and/or a change in temperature.	4.28/4.18	3.5	
(5) Determine longitudinal stress (σ_l) and hoop stress (σ_h) for a thin walled pressure vessel.	4.31/4.28	4	Overall good understanding.
(6) Analyze and design circular members in torsion, including calculating shear stresses (τ) and angles of twist (ϕ).	4.10/4.29	4	Ok with calculating τ; weaker on ϕ.
(7) Draw shear and moment diagrams for a beam.	4.42/4.44	4.5	Good overall understanding.
(8) Determine normal flexure stresses (σ) for a beam.	4.05/4.13	4	
(9) Determine transverse shear stress (τ) at any point on a beam cross section.	3.96/4.05	3.5	Problems calculating 'Q'.
(10) Design a prismatic beam.	3.94/3.96	4	
(11) Calculate stresses in a member subjected to combined loading due to axial, torsional, internal pressure (i.e., thin wall pressure vessels), and/or bending forces.	3.85/4.03	3	
(12) Calculate beam deflections.	3.92/4.08	3.5	
(13) Analyze and design columns	4.01/4.20	4	Not hard, but jammed in at end of course.

Table 2: Assessment of Course Contributions to Program Outcomes

HOW DOES EM364/A CONTRIBUTE TO THE PROGRAM OUTCOMES?

1 – No Contribution 2 – Small Contribution 3 – Moderate Contribution 4 – Large Contribution 5 – Very Large Contribution

	Program Objective Table			
	Produce Civil Engineering graduates who demonstrate:	**Activity**	**CD Assess**	**Explain Course Director's Assessment**
1	Apply the engineering thought process to design CE components and systems	All Problem Sets, EDPs, and In-Class Problems	5	All problem sets, EDPs, and in-class problems require the cadets to apply the ETP throughout the course.
2	Creativity	All Problem Sets, EDPs	2	Not much room for creativity in straight forward problem sets; this course is the initial introduction to design
3a	Proficiency in structural engineering	All Problem Sets, EDPs, and In-Class Problems	4	Excellent integration of structural engineering concepts through the course.
3b	Proficiency in environmental engineering	None	1	
3c	Proficiency in hydrology & hydraulic engineering	None	1	
3d	Proficiency in geotechnical engineering	None	3	Use of Mohr's Circle supports CE 371
4a	Proficiency in mathematics	Problem Sets, EDPs, & In-Class Problems & Derivations	5	Problem sets and in-class problems require calculus, trigonometry, and linear algebra
4b	Proficiency calculus-based physics	Problem Sets, EDPs, & In-Class Problems & Derivations	3	Frequent use of equilibrium.
4c	Proficiency general chemistry	None	1	
5	Design and conduct experiments, and analyze and interpret data	Conduct, Analyze, & Interpret Data	3	Lab design will be introduced in 02-2
6	Function on multidisciplinary teams	None	1	
7	Roles and responsibilities of civil engineers and the issues / professional practice	Class Discussions in Aspects of Design	2	Appropriate level for this course
8	Use the modern engineering tools necessary for engineering practice	Problem Sets, EDPs, & In-Class Problems	3	Spreadsheets, calculators, stress-strain curves, steel tables, S-N curves, etc.
9	Write effectively	Lab & EDP Reports	5	Students turn in 6 written technical reports
10	Speak effectively	In-Class Discussions	2	Most students called on at least once per class.
11	Knowledge of contemporary issues	Student Discussion	2	We do bring current engineering issues into the classroom; develop an interest board in the classroom.
12	Broad education to understand the impact of engineering solutions in a global/societal context	In-Class Discussions and EDPs	2	Mostly sidebar discussions as issues arise, primarily before and after class.
13	The preparation for and willingness to pursue continued intellectual and professional growth	In class discussions, Particularly Lsns #1 & #40	3	Broad applicability of Mechanics excites students and shows cadets that they are attaining the skills to continue their education as structural engineers

The course content, course objectives, and lesson objectives agreed to in the course assessment meeting form the baseline the course director uses to develop his board notes, examination questions, and homeworks the following year. The goal is to both increase student learning and the students' enjoyment of the course, with the desired effect of motivating and inspiring them to continue to learn.

Assessment

Doing things well makes a difference in student motivation and learning. We will present some of the student free-form comments about exams and grades from two semesters with the same instructor and identical student populations. Then we will provide our assessment of the comments. Note that all student comments and the data used in Figure 2 below were collected using an anonymous web-based survey administered at the end of the semester.

Representative student comments from the Fall 2000 semester, (Academic Year 01-1)

- The workload for this course is far too much. The average time to do a problem set was on average about 3 hours without doing the regular class homework.
- They did not teach the material in class that could be used very well on the problem sets, or exams.
- This was one of the engineering courses that needs to be revamped. It overemphasized performance over learning… we were given homework assignments that required us to apply numerous concepts, some of which may not have been immediately apparent and in the end grades and the learning process just died.
- I felt the homework problems were way too difficult. Instead of being a means to help my grade it in fact hindered my grade. I also thought the exams were not fair, especially exam 3.
- The exam's seemed too different from the problems covered.
- P did a good job of teaching us the material.
- The graded homework assignments take a really long time…
- It seemed that I had to work a lot harder for my grade in this course than in any other.
- This course, far by, has got to be the hardest course I have ever taken in my life. It has taught me what real hard work meant to do well. I understand now what it means to study hard, getting help from the P often and working together with classmates. If I had worked hard in the beginning of the semester as hard as I did the end of the semester, I would have done awesome. My P was one of the most motivated P's I had so far in my cadet career. He knows his stuff, and he enjoys being here. He'll do anything to help a cadet; stay late hours after school to work with cadets.
- Too much work.
- CPT Vander Schaaf is a very good instructor and shows superb understanding of the concepts he is instructing.
- I thought that this course graded much harder than any other course and that it also demanded more work on graded assignments than any of my other courses.
- I think I know the material a lot more than my grade reflects. This was my favorite class this semester, but I currently have a C.
- This course was my least favorite of my engineering courses. I always felt overwhelmed by the material and they kept piling it on. It seemed more like a chore that I didn't want to participate in as opposed to my other engineering courses where I felt a desire to learn. I

got a negative feeling about it as soon as we started and I still do not like the course. I think I would really enjoy the material and really would like to have a solid understanding of it, but the actual class had the opposite effect.
- After taking this course I was glad that I changed my major from Civil Engineering.
- I was very unhappy with the number of FRAGOs (issued changes) necessary for our homework problems and design problems. Many of the mistakes which were later corrected demonstrated minimal (instructor) forethought.
- This course was by far the most unrealistic course. The course average for exam 3 was a 72%. That is way to low. If 33 people fail an exam there is something wrong. I like my instructor but the amount of work was very hard. The examples they gave us in class were very easy examples of the concept, then they would ask us the hardest part of the concept on the test. That is not what learning is about. We are not engineers yet. They did not set us up for success in Mechanics of Materials.
- Should demonstrate a greater regard for cadet's grades. A bell curve centered at C is not always how it has to be.
- The course just wasn't fun--it was more of a burden than learning.

Representative student comments from the Fall 2001 semester, (Academic Year 02-1)
- I really enjoyed coming to materials. It makes me glad that I chose to be a civil major.
- There should be more exams, so too much information is (not) crammed into the exams.
- Good course, I don't have any complaints.
- My best instructor here. Very enthusiastic, mastery of material, and always willing to help.
- The course was interesting and well structured, and the instructor was motivated and objective.
- The example problems that the instructor used during class helped me understand the material.
- The realistic problems presented in the course were the great strengths of the curriculum.
- I thought my instructor prepared us as well as any instructor I've had at the Academy by letting us know what would be expected of us, and then making sure that we would be able to perform those tasks.
- Homework sets were very relevant and the material covered, and the manner in which it was covered, was very representative of what we saw on the exams.
- This was a great course that gave me a whole new perspective on buildings and how they were constructed. My instructor also did a great job in teaching the material in a way that I was able to learn it.
- The course was very demanding but very valuable to my learning.
- I enjoyed the course and the instructor a lot. Very informational

The course content and course objectives did not change between the semesters, as illustrated by the consistent student responses to the course structure (Figure 2) and learning objectives (Table 1). Only the USMA (A & B) and Department (C) web based questions pertaining to the subject at hand are presented for brevity. The question “My instructor used well articulated learning objectives to guide my learning” scored 4.52 in AY 01-1, and 4.58 in AY 02-1 (Figure 2). The question “My instructor had a structure or plan for every lesson's learning activities" scored 4.93 in AY 01-1, and 4.90 in AY 02-1 (Figure 2). All of these scores are between the 'agree' and the 'strongly agree' response, demonstrating that the students considered the course to be very well developed and structured. The difference between these responses for the two semesters was statistically insignificant. Overall, the students rated the course structure and the classroom instruction equally highly both semesters (Table 2 and Figure 2).

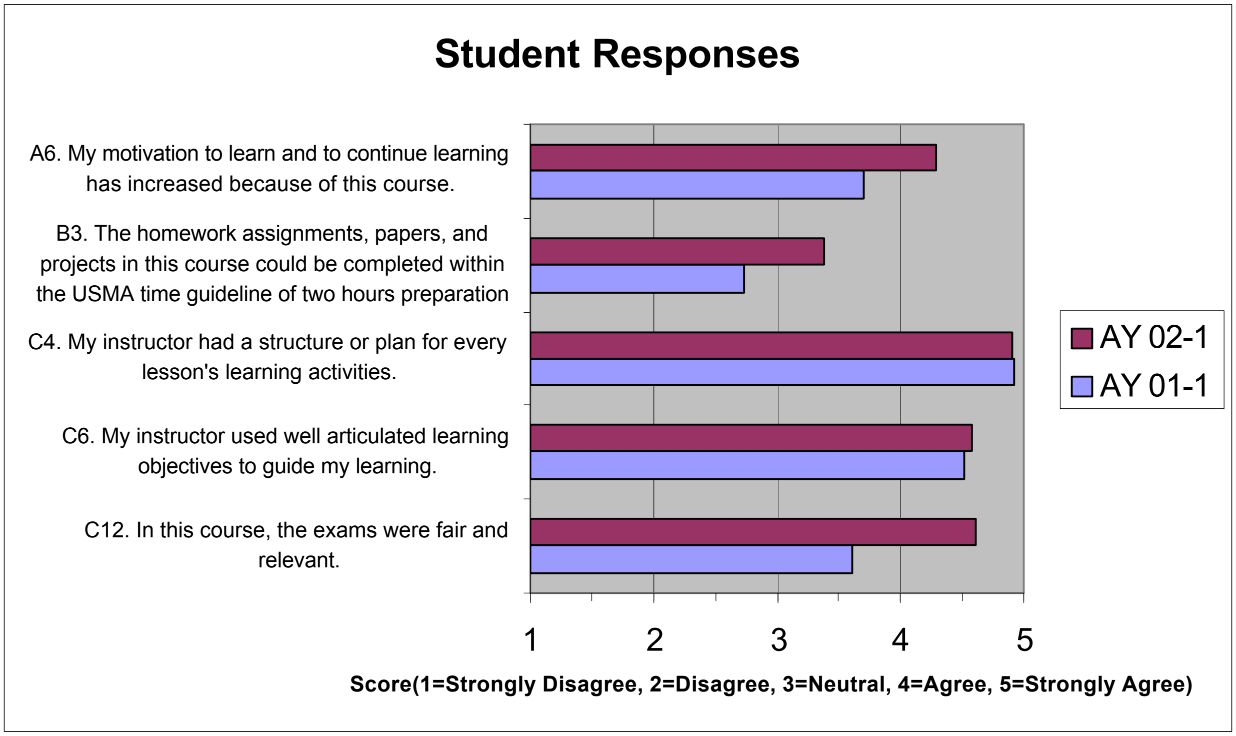

Figure 2: Student Web-Based Responses to End of Course Questions

The students perception of the course changed significantly between the semesters, as illustrated by the student comments above and the responses to the questions concerning motivation to learn, fair and relevant examinations, and length of assignments shown in Figure 2 above. The student response to the question "The homework assignments, papers, and projects in this course could be completed within the USMA time guideline of two hours preparation for each class attendance" increased from 2.57 in AY 01-1 to 3.03 in AY 02-1, indicating that the students found the assignments took less time to complete in AY 02-1. This is despite the fact that the time surveys (at the start of every lesson, the students are asked to report the amount of time they have spent on the course material since the previous lesson) the students fill out at the beginning of every lesson showed an **increase** in the amount of time spent on the course, while the exit grades in the course remained essentially constant. The students reported spending an average of 86.0 minutes per lesson in AY 01-1 verses 96.9 minutes per lesson in AY 02-1, an increase of 13% in the amount of time students spent on each lesson. However, as the student comments above illustrate, the students perceived their workload to be much higher in AY 01-1.

The students reported significant increases in their "motivation to learn and to continue learning", 3.65 in AY 01-1 verses 4.03 in AY 02-1 (Figure 2); and the response to "In this course, the exams were fair and relevant" went from 3.54 in AY 01-1 to 4.23 in AY 02-1. The reason for this increase in student motivation to learn and continue learning can be found in the student comments above. In the Fall 2000 semester, there are numerous comments about "graded homework assignments take a really long time" and "the homework problems were way too difficult". Because the homework problems did not follow well from the concepts and example problems presented in class and some were poorly written, students struggled with the problems, and often gave up out of frustration. The homework problems were completely revamped for the Fall 2001 semester. In general, more questions were asked per homework assignment, with care taken in problem complexity, and all homework problems were solved by an instructor before issuing the homework to students. A problem that required a relatively straight forward application of the concepts taught would be asked first, with the problems building in complexity. Previously, there was often only one relatively complex problem asked per topic. Additionally, pertinent real world problems were used. Instead of receiving a generic problem with force arrows on it, and being told to solve, the questions often came from problems or projects the instructors had worked on as junior officers in the Army. For example, one of the homework questions asked under the topic of axial deformation was solving the statically indeterminate analysis problem for the factor of safety in the rebar and in the concrete for the footings of a water tower an instructor had recently been in charge of constructing in Thailand. The end result was students spent more time working on the assignments, as shown in the time survey data discussed above, but student complaints about workload were almost eliminated, and the students perceived the assignments as taking less time, illustrated by their response to question B3 in Figure 2 above about the length of time it took to complete assignments.

The student comments also show a significant change in student perception of the exams and the grading policy. A typical comment from Fall 2000 was "The exams seemed too different from the problems covered" with many student comments expressing dissatisfaction with grades. A typical comment from Fall 2001 was "Homework sets were very relevant and the material covered, and the manner in which it was covered, was very representative of what we saw on the exams." However, grading philosophy and final student grades were consistent between semesters.

In his book, Lowman states "Making tests difficult by focusing on unimportant details induces anxiety, gamesmanship, and a sense of unfairness. It is better to design tests that will motivate students to learn critical content than to reward them for memorizing trivia. Neither student motivation nor learning is fostered by putting surprises on exams."[4] The authors of this paper couldn't agree more.

Conclusions

The goal is to increase both student learning and enjoyment of the course, with the desired effect of motivating and inspiring them to continue to learn. Both the student comments and the students' responses in Figure 2 above show that Mechanics of Materials was much more effective at motivating and inspiring the students during the Fall 2001 semester than during the Fall 2000 semester. Although the students found the course to be equally well structured both semesters, and had the same instructor who received similar positive students comments, student perception of the course, their enjoyment of engineering, and their motivation to continue learning were very different. A telling student comment from Fall 2000 was "After taking this course I was glad that I changed my major from Civil engineering." Contrast this with a student comment from Fall 2001 "I really enjoyed coming to materials. It makes me glad that I chose to be a civil major." The course structure, course objectives and lesson objectives were the same for the two semesters. The primary change in the course was the change in the homework and exams. More questions were asked per homework assignment, with care taken in problem complexity, and all homework problems were solved by an instructor before issuing the homework to students. Additionally, pertinent real world problems were used on both homeworks and exams. Exams were carefully crafted following the methodology discussed in this paper. The end result was students spent more time working on the assignments, as shown in the time survey data (86.0 minutes per lesson in AY 01-1 verses 96.9 minutes per lesson in AY 02-1), but student complaints about workload were almost eliminated, and the students perceived the workload as taking less time. The end result was a significant increase in student enjoyment of the course and material, satisfaction and renewed commitment to becoming civil engineers, and an increase in student motivation to learn and continue learning.

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